THE INTEGRATED METEOROLOGICAL SYSTEM (IMETS) WEATHER SUPPORTING CONCEPT

Richard J. Szymber
US Army Research Laboratory
Fort Huachuca, AZ 85613

MAJ Mike Corbett
US Army Intelligence Center & Ft Huachuca
Fort Huachuca, AZ 85613

ABSTRACT

This paper describes objective IMETS capabilities envisioned in the 2005 timeframe to include: a) battlespace observing systems and data sources ingested by IMETS; b) IMETS connectivity and interoperability with the Air Force Tactical Forecast System (TFS) and Defense Meteorological Satellite Program (DMSP) Small Tactical Terminal (STT); c) weather support products and data provided to Army battlefield functional areas and operating systems, and other "warrior C4I" systems; and d) IMETS communications connectivity and dependencies within the tactical weather support structure, and interaction with the Army Battle Command System (ABCS). We will overview the weather architecture and key concepts essential to fully exploit the capabilities of IMETS and enable warfighters to ultimately "own the weather."

1. INTRODUCTION

The most significant improvement in Army weather equipment over the next few years is the fielding of IMETS, and it's reception of real-time DMSP data. This will down-size and automate collection/ingest, processing, product preparation, and dissemination of weather information to all echelons of command in wartime and stability/support operations. Combined weather observations over the entire battlespace will be built into a three dimensional data base and stored in IMETS. IMETS will use the current observation data base and synoptic forecasts prepared by Air Force Global Weather Center (AFGWC) to generate detailed, tailored mesoscale forecasts, that will serve as the source of input for Tactical Decision Aids (TDAs) and automated Intelligence Preparation of the Battlefield (IPB) weather analysis products. Weather effects TDAs, like the Integrated Weather Effects Decision Aid (IWEDA), will run on IMETS, Digital Topographic Support System (DTSS) , All Source Analysis System (ASAS) , Maneuver Control System (MCS), and other nodes of the ABCS. The TDAs run by users outside IMETS will have electronic 1 inkage to IMETS through area communication networks to receive the weather information required. Users will be able to receive electronically tailored weather data and products made to meet their mission, software, and operational requirements.

The IMETS is an Intelligence and Electronic Warfare (IEW) system of the ABCS. IMETS is Army furnished equipment that is manned and operated by US Air Force Weather Teams (WETM) at echelons above corps, corps, division, aviation brigade, separate brigade, armored calvary regiment, and ranger regiment/special forces. It is a heavy High Mobility Multi-Purpose Wheeled Vehicle (HMMWV) mounted tactical system deployable with supported high speed forces. IMETS is a mobile, automated weather information processing and communications system that will carry Army weather support into the 21st century. The target date for the weather supporting concept outlined here is 2005.

2. ARMY TACTICAL WEATHER SUPPORT PROCESS

-The focus of all weather support to the Army will be upon the production and dissemination of information and decision aids - mainly TDAs - needed to conduct battlefield operations. Three sequential processes are used to provide Army tactical weather support. The first step is the collection of meteorological observation and forecast data. The next phase is the automated ingest, collation, validation, processing, analysis, and application of data and forecasts to predict effects. The final process involves the automatic, electronic dissemination of weather effects products to the user, primarily in the form of tactical decision aids.

With respect to the tactical Army weather support process as it relates to the IMETS, this paper will focus on the four stages that lead to Owning the Weather (OTW). The four components in order are: 1) "know the weather" - observations/collection; 2) “predict and apply the weather” - processing, analysis, forecasting, data/product generation, and dissemination; 3) 'Understand and exploit the weather" - TDAs, battlefield visualization, and information operations; and 4) "own the weather" - combat force multiplier. OTW provides the capability to anticipate the differential impacts of weather conditions on friendly and threat capabilities, allowing commanders to exploit windows of opportunity created by the weather.

3. KNOWING THE WEATHER

Weather observations are the foundation for weather forecasts, advisories/warnings, and weather effects information and TDAs. More frequent observations taken in a smaller area are a necessary part of improving mesoscale and microscale forecasts. IMETS will collect environmental observations and data from all available sources. Current and forecast synoptic and regional scale meteorological data and products are received in a timely manner from central facilities and centers. This information is supplemented by real-time, local battlefield weather observations received from sensing systems and observers. The goal is to build the most complete, detailed and accurate weather database for running atmospheric models, TDAs, and other applications.

3.1 Central Facilities/Centers

Strategic and theater weather data sources for IMETS are AFGWC, Fleet Numerical Meteorology and Oceanography Center (FNMOC), Air Force Combat Climatology Center (AFCCC), Air Force Space Forecast Center (AFSFC), National Oceanographic and Atmospheric Administration (NOAA), World Meteorological Organization (WMO), and Joint Meteorological Forecasting Units (JMFU) and Theater Forecasting Centers (TFC). The primary data source is AFGWC, with data and products from all other sources, except JMFU/TFC, available through AFGWC.

Vital battlefield surface, upper-air, and airborne observations must be relayed back to higher echelons and central forecasting facilities by IMETS via terrestrial lines such as Secret Internet Protocol Router Network (SIPRNET) or Global Command and Control System (GCCS). Since Army units are mobile and location must be included as part of the weather observation report, these reports are classified and must be transmitted over secure communications.

3.2 Real-time Battlespace Observations

IMETS will acquire local observational data from a variety of complementary space based, airborne, and ground based automatic remote and in-situ sensing systems, and human observers. In particular, the Army requires local area observations forward of division command posts and in target areas deep into enemy territory.

Observations from meteorological satellites (METSAT) provide the best area coverage, globally, and in theater. IMETS will directly receive low and high resolution imagery (visible, infrared, and microwave) and atmospheric soundings from polar orbiting DMSP and NOAA/TIROS satellites (to be replaced by the converged National Polar-Orbiting Operational Environmental Satellite System (NPOESS) around 2006), and Russian METEOR and Chinese FENG-YUN satellites. High temporal resolution observations from the geostationary METSAT, GOES (United States), METEOSAT (Europe) and GMS (Japan), will also be directly received by IMETS.

Airborne observations in crucial forward and deep areas will eventually be provided by an automatic meteorological sensor onboard unmanned aerial vehicles (UAV) and dropsondes ejected by UAV over critical target areas. These atmospheric profiles from dropsondes released at maximum flight altitude and flight path measurements from the meteorological sensor will come from a family of UAV flying at different altitudes and ranges/depths in the battlespace. The UAV-Tactical (i.e., Outrider) will have a maximum range past the forward line of own troops (FLOT) of 50 km and maximum flight altitude of 3 km above ground level (AGL) at 7 hour time endurance. At 4.5 hour endurance, it's maximum range past the FLOT is 200 km and maximum altitude is 6 km AGL. The UAV-Short Range (Hunter) will have a maximum range of 200 km and altitude of 4.5 km AGL. The UAV-Endurance (Predator) will fly out to a range of

500 km at a maximum altitude of 7.5 km. And the UAV-Medium Range will have a maximum range of 650 km and altitude of 12 km. Present weather information (e.g., clouds, precipitation, visibility) can also be obtained from UAV visible and infrared video camera imagery. Other airborne observations that can be received by IMETS include Air Force and Army aviation pilot reports (PIREPS) and target weather information (TARWI).

Upper air observations, up to an altitude of 30 km AGL, are taken near artillery units by Artillery Meteorological (ARTYMET) sections with the Meteorological Measuring System (MMS), using the Computer Assisted Artillery Meteorology (CAAM) models and software. Eventually, after the year 2005, tactical atmospheric profilers (i. e., the Profiler) will provide vertical profiles with extremely -rapid refresh rates. IMETS will also receive upper air profiles from Air Force WETM taken at fixed airfields.

Several automatic, remote surface sensing systems will provide IMETS with surface weather observations taken at different areas on the extended battlefield. These unattended sensing systems will be selectively deployed throughout the depth of the battlefield and tied into an automated communication system. Brigade and battalion S2 sections will provide surface weather data taken at key terrain points forward of division command posts with hand emplaced and vehicle mounted Automatic Meteorological Sensor Systems (AMSS). Also, the S2 section's Improved Remotely Monitored Battlefield Sensor System (IREMBASS) with AMSS (IRAMSS) will provide surface observations in forward close battle areas and flanking areas along likely enemy avenues of approach. The IRAMSS can be hand emplaced or air delivered from the FLOT to deep behind enemy lines. ARTYMET sections will provide surface observations near artillery batteries taken by the MMS's automated surface meteorological sensor. Surface observations for deep areas will be received by IMETS from the Remote Miniature Weather Sensor (RMWS) deployed by Special Operations Forces (SOF). Finally, rear area surface observations will be taken by the Air Force WETM at IMETS locations.

Human manual surface weather observations taken all over the battlefield will also be obtained by IMETS. Long range ground reconnaissance and surveillance elements/units will provide surface observations for close battle and deep areas. Observations for areas forward of divisional command posts will be provided by the S2 Forward Area Limited Observing Program (FALOP), the ARTYMET section Artillery Limited Surface Observation Program (ALSOP), and Engineer units. Rear area weather observations will be taken by Air Force WETM observers at airfields and IMETS locations, Air Traffic Control (ATC) units, and Army aviation brigades/squadrons.

Other potential sources of observational data for IMETS may include Air Force Tactical Weather Radar (TWR) and tactical lightning detection/location systems, DoD/INTEL satellite imagery interpretation elements, Artillery Global Positioning System (GPS) rocketsondes (for deep operations support), and other theater Air Force, Navy, Marines, and indigenous sources.

4. PREDICTING AND APPLYING THE WEATHER

The four main areas of IMETS functions and capabilities to be discussed here are data ingest, processing/forecasting, product preparation, and dissemination. The most critical element of tactical weather support is weather communications. It is also the most difficult aspect to consider for establishing a future objective architecture. Tactical weather communication systems must provide dependable, wireless, two-way communications. The primary method of communication will be satellite based, with high frequency (HF) radio providing a secondary means of communication. The objective concept is to have a "single data stream" which travels over an open systems, common-user network, using satellite based system like Global Broadcast Service (GBS) and common-user -networks such as SIPRNET.

Original IMETS organic communications equipment include Mobile Subscriber Equipment (MSE), Combat Net Radio (CNR) Single Channel Ground and Airborne Radio System (SINCGARS), HF radio, and Systems West METSAT receiver. Eventually, IMETS will be supplemented with the STT and satellite communications (SATCOM) equipment, and MSE will be replaced by Warfighter Information Network (WIN) and SINCGARS will be replaced by Future Digital Radio (FDR).

4*1 Communications for Acquisition/Ingest

IMETS will receive data and products from AFGWC primarily through GBS and SIPRNET. The AFGWC personal computer based dial-in access system, Air Force Dial-In Subsystem (AFDIS), can also be used through the IMETS' forecaster workstation TFS software. A variety of networks and systems can be accessed through SIPRNET to provide IMETS connectivity to AFGWC. A few such hosts include: GCCS; Joint Worldwide Intelligence Communications System (JWICS) ; Joint Deployable Intelligence Support System (JDISS); WIN; the integrated Intelligence information service INTELLINK; and the AFGWC homepage, Air Force Weather Information Network (AFWIN). The AFGWC primary uplink peak data rate for GBS is expected to be about 64 Kbps to support IMETS with GBS ground receiving terminals. Data and products from JMFU, TFC, and indigenous sources will be received by IMETS mainly through Theater Deployable Communications (TDC),High Frequency Regional Broadcast(HFRB)system, WIN, and GCCS.

Real-time battlefield observational data will be acquired by IMETS through various means, depending on the particular observing system. Automated sensor systems will be linked electronically to IMETS through self-contained communications, standard Army communications systems, or up-linked via satellites. IMETS will have a direct readout capability to receive all available METSAT transmissions. IMETS' Systems West will receive polar-orbiting METSAT Automatic Picture Transmission (APT) imagery and geostationary METSAT Weather Facsimile (WEFAX) imagery and other products. The STT will directly receive DMSP Realtime Data Smooth (RDS) and Real Time Data (RTD) transmissions, NOAA/TIROS High Resolution Picture Transmission (HRPT) data, and geostationary

METSAT low and high resolution imagery. All data received by the STT, and products it generates, will be ingested into the IMETS TFS on the forecaster workstation through an internal Local Area Network (LAN) line. All UAV meteorological data will be received by IMETS through the UAV tactical ground control station via MSE/WIN. ARTYMET upper air profiles and other data will be transmitted to IMETS through MSE/WIN. SOF RMWS observations will be received by IMETS through SATCOM link. AMSS data will be relayed to the S2's AMSS monitor/programmer unit by line-of-sight radio link. The S2 can store, display, and print the weather data on the monitor station and forward the data to the nearest IMETS and ASAS. IRAMSS data will be relayed to the S2's IREMBASS monitor/programmer station by 599-channel synthesized radio frequency (RF) data link, with a 25 ms burst transmission and 15 km -line-of-sight range for sensors and repeaters. The IREMBASS monitor station stores, displays, prints, and forwards the weather data to IMETS and ASAS. The S2's AMSS and IRAMSS data will be transmitted to IMETS via area communications (i.e., IMETS will receive the data by hard wire line or through SINCGARS/FDR).

4.2 Processing, Analysis, Forecasting, and User Product Generation

The key to IMETS producing tailored weather effects forecasts is the timely, automated processing of current battlefield weather data/observations, together with central or networked weather facility products and forecasts. Unique IMETS processing and forecasting capabilities focus on the production of high resolution, local area forecast gridded data and graphic displays that will feed directly to IMETS and other user system client software applications. IMETS ingest, processing, analysis, forecasting, product preparation, and dissemination functions reside on the forecaster and weather effects workstations.

The forecaster workstation hosts the Air Force TFS software which ingests and processes alphanumeric, graphic, and gridded data from AFGWC and JMFU/TFC. The TFS provides theater weather forecasts out to 72 hours or more, and other standard TFS products. TFS also ingests, displays, and provides all STT METSAT imagery/data and products. The forecaster workstation passes data/products to the weather effects workstation (WEW) for further processing and generation of tailored products and TDAs.

WEW models and software applications include: the Battlescale Forecast Model (BFM); Atmospheric Sounding Program (ASP) ; IWEDA; Weather Maker program; Air Force Electro-Optical TDA; Night Vision Goggles TDA; Army Electro-Optical System Performance - Target Acquisition Ranges TDA, Thermal Reversals/Crossover TDA, and Weapons Zones TDA; Nitelite and EOCLIMO TDAs; Terrain Evaluation Module (TEM) with Digital Terrain Elevation (DTED) Level 1; Joint Mapping Tool Kit; and communications management functions. The WEW ingests AFGWC data and current battlefield meteorological observations to initialize the BFM, and can contour, streamline, and overlay BFM output on terrain map backgrounds of the area of operations.

Detailed weather forecasts tailored to the specific operational and tactical environment will be provided by IMETS using the BFM. This battle-scale or mesoscale meteorological model produces forecasts of weather conditions for a more limited region than the usual large-scale forecasts and includes the effects of complex terrain on atmospheric conditions. Currently, the BFM is initialized by the Navy Operational Global Atmospheric Prediction System (NOGAPS) every 12 hours via AFGWC. Eventually, AFGWC will acquire a high resolution mesoscale numerical weather prediction model that will be used for BFM initialization. Initializing the BFM with higher resolution gridded fields improves it's mesoscale forecasts. BFM has a 24 hour forecast period with forecasts at 0, 3, 6, 9, 12, 18, and 24 hr. It has 3 modes of area coverage and horizontal resolution: 500 x 500 km area (grid size) at 10 km resolution (grid point spacing); 250 x 250 km area at 5 km resolution; and 100 x 100 km area at 2.5 km resolution. The BFM has high vertical resolution in the lower atmosphere, i.e. , 16 vertical levels from the surface to 7 km AGL, with greatest distribution of levels near surface. The weather parameters it forecasts are wind speed/direction and gusts, moisture (dew point, relative humidity, etc.), temperature, pressure, cloud cover (cloud liquid water) , non-convective precipitation, precipitation type, and snow amount.

The ASP is an automated weather hazards and Skew T/Log P program that is coupled to the BFM. Combining current data and BFM output, ASP predicts atmospheric moisture, convection, and other parameters anywhere over the BFM's coverage area. Specifically, it forecasts the following weather parameters at all BFM grid points: visibility, cloud coverage and ceiling, fog , turbulence, wind shear, icing, thunderstorm probability, precipitation, atmospheric stability, and inversion layers.

The IWEDA is a sophisticated expert system based on hundreds of identified weather sensitivities of Army, Air Force, and threat weapon systems and operations. It automatically identifies and provides favorable, marginal, and unfavorable weather-effects impacts based on operating limitations of both friendly and threat weapons systems, their subsystems and components, personnel, and missions with respect to time and area of operation. IWEDA is tailored to specific tactical operations and missions, and provides detailed weather impacts information in terms of what operations and equipment are effected, as well as when, where, and why they are effected. Real map backgrounds are used to overlay geographic weather impacts for particular weapon systems, subsystems, or components. The user can query the program to display detailed textual weather impact statements for a specific location on the battlefield. Output is in readily understood color coded matrices (red = unfavorable, amber = marginal, and green = favorable conditions) , map overlays, and succinct text statements. A "what-if" wargaming feature allows the user to quickly look at alternative mission/system setups and weather conditions. The BFM and ASP, together with additional forecaster inputs, automatically drive IWEDA. IWEDA will also be used on other Army command and

control (C2) systems to allow tactical customers to obtain weather effects information at all organizational levels.

IMETS will automate product generation as much as possible by providing the WETM the tools to build, automate, store, and recall products, and enable client pull of data and products. The WETM will build product templates, which will automatically draw on the IMETS database to fill in template fields, and which can be stored and recalled for later use. The forecaster workstation and WEW produces and disseminates processed data and products such as observations, forecasts, advisories/warnings, messages, graphics, imagery, tailored weather effects information, and automated weather effects TDAs. Data and products can be pushed to users or pulled from the IMETS server by client customers. The main Army -functional areas supported are IEW, fire support, maneuver, aviation, IEW, air defense, engineer, and combat service support.

4.3 Communications for Dissemination

IMETS connectivity to all Army customers/users is accomplished through the ABCS. IMETS will operate in the same common operating environment as the Battlefield Operating Systems (BOS) and C2 systems it serves. IMETS data and products can be sent to or retrieved by any BOS and C2 system with access to the ABCS. These products are available on the LAN through a client server architecture. IMETS at highest echelon builds the weather database and exchanges products/data with lower echelons. IMETS connectivity to users within each echelon is by LAN and its connectivity between echelons is through a Wide Area Network (WAN) via SIPRNET, WIN, and CNR.

IMETS ABCS communications systems will be primarily the Army Common-User System (ACUS) MSE/WIN and secondarily the CNR SINCGARS/FDR. ABCS components vary by echelon. At echelon above corps, IMETS will be directly connected to the Battlefield Functional Area (BFA) C2 systems by the Army Global Command and Control System (AGCCS). At corps and division, IMETS will be directly connected to BFA C2 systems and BOS by the Army Tactical Command and Control System (ATCCS). IMETS will be indirectly connected to brigade and battalion BOS and C2 systems by the Force XXI Battle Command-Brigade and Below (FBCB2). The AGCCS is the Army component of the GCCS and provides the primary link to joint and combined systems.

A "smart push" will be used to send routine data and products to systems with formal user interface requirements (UIR) with IMETS. The IMETS server will send gridded data (and other information) to client applications on BOS and C2 systems directly from IMETS or through the MCS (the tactical forces information system), as specified in UIR. Additionally, a client-server "direct pull" will be used for data/products which are not routinely pushed and are made available to access as they are needed. One form of direct pull will be via an IMETS homepage/menu system.

GBS is a multicast system, allowing simultaneous broadcast of a variety of data/products. The system can provide these products to all users, a small subset of users, or a single user, depending on how the information is addressed and/or routed. The GBS allows two types of uplink: primary site and mobile inject. From tactical injection points, IMETS can use GBS to smartly push data/products to Army users with GBS ground receiving terminals, particularly those at brigade and battalion. IMETS mobile inject uplink peak data rate for GBS will be approximately 64 kbps.

IMETS will host a homepage server and browser accessible via the SIPRNET to get weather information and products especially to users without access to a C41 interface and to provide enhanced interoperability with joint meteorological systems. All WEW, STT, and forecaster workstation user products can be saved to the IMETS homepage. The homepage/menu will be organized in two broad categories by echelon and mission/BOS.

5. UNDERSTANDING AND EXPLOITING THE WEATHER

The ABCS, battlefield visualization, TDAs, and information operations provide the understanding and means to exploit the weather and it's battlefield effects.

5.1 ABCS BOS and C2 Systems

IMETS enables the warfighter to understand and exploit the weather by providing their ABCS BFA systems with products in the form of weather data fields, preprocessed TDAS, specially tailored output fields for other specific TDAs, and - in the far term - automated virtual reality displays of weather conditions linked to terrain displays. These products will be utilized in maneuver, targeting, and fire support; mission planning and rehearsal systems, and wargamming tools; models and simulations; TDAs; and other weather-related system applications. Systems with IMETS supported software applications, tools, and TDAs will include: AGCCS, ASAS, DTSS, MCS, Advanced Field Artillery Tactical Data System (AFATDS) and MMS, Forward Area Air Defense C3I (FAADC3I) system, Combat Service Support Control System (CSSCS), Automated Nuclear Biological and Chemical Information System (ANBACIS), Aviation Mission Planning System (AMPS), and UAV Mission Planning and Control Station.

5.2 Weather IEW Information Operations (IO)

The objective of weather IO is to guarantee and maximize our capability to anticipate and exploit the weather to our advantage while simultaneously denying the enemy the ability to use or manipulate the weather to their advantage. This is accomplished by protecting our access to, integrity of, and use of our weather information systems (INFOSYS), and to exploit and attack the enemy's weather INFOSYS.

The three components of weather IO are weather intelligence, INFOSYS, and C2 warfare (C2W). Weather intelligence concerns

automated IPB weather analysis, battlefield visualization of the environment/effects, and automated weather effects TDAs. Weather INFOSYS is comprised of IMETS and other weather support systems and infrastructure. Weather C2W involves weather information warfare consisting of weather C2W-protect and C2W-attack. Weather C2W-protect entails plans and actions to protect and secure our weather support INFOSYS (systems, databases, computers, communications, and personnel). Weather C2W-attack includes physical destruction or disruption of the enemy's weather INFOSYS to deny them weather information, understanding the enemy's weather INFOSYS to intercept and utilize their information and/or to influence/modify their weather picture, and limited tactical weather modification.

6. OWNING THE WEATHER (OTW)

OTW is the use of advance knowledge of environmental conditions, and their effects on friendly and enemy soldiers, systems, operations, and tactics, to gain a decisive advantage over opponents. It involves improving and exploiting the weather-related technological advantages for our battlefield systems over threat systems, making adverse weather a combat force multiplier. For decisive victory, the force exchange ratio can be increased to approximately 20-to-l as a result of both Owning the Night and OTW.

IMETS is the centerpiece of OTW. The key ingredients for OTW are seamless communications, accurate and detailed weather forecasts, and a complete database of environmental sensitivities (i.e critical threshold values) of friendly and threat equipment, weapons systems and operations. The ABCS and IMETS' communications equipment, BFM, and IWEDA provide these essential capabilities necessary to anticipate and exploit the weather for tactical advantage.

7. CONCLUSION

The commander who can best measure and take advantage of weather conditions has a decided advantage over his opponent. By understanding the effects of weather, seeing the opportunities it offers, and anticipating when they will come into play, the commander can set the terms for battle to maximize his performance and take advantage of limits on enemy forces. An effective "all weather" mission capability can be achieved through the selection of the appropriate mix of sensors, weapons systems, and tactics that give friendly forces the ability to see, maneuver, fight and win in all types of weather.

IMETS satisfies the Army's requirement for an automated method of ingesting, processing, preparing and disseminating weather information and effects for the warfighter. IMETS provides commanders and their staffs with known and predicted conditions in the air and on the ground. This enables them to plan for conditions and their effects before a battle, helping the commander to choose the best time, manner, and place of engagement.